

WE CLAIM:

1. A process for cleaning a workpiece with a cleaning medium, comprising:

5       contacting said workpiece and said cleaning medium in a cleaning vessel under conditions such that said workpiece is exposed to a single fluid phase of said cleaning medium, wherein said contacting is carried out for a period of time sufficient to clean said  
10 workpiece.

2. The process of claim 1, further comprising:  
introducing inert gas into said cleaning vessel;  
and

15       maintaining said cleaning vessel at a first temperature and first pressure, said first temperature and said first pressure being sufficient to produce said single fluid phase.

20       3. The process of claim 1, further comprising:  
introducing inert gas into a solvent delivery vessel;

introducing co-solvent and carbon dioxide to said solvent delivery vessel to form a cleaning medium at  
25 said single fluid phase; and

maintaining said solvent delivery vessel at a second temperature and second pressure, said second temperature and said second pressure being sufficient to produce said single fluid phase.

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4. The process of claim 1, further comprising:

purging said cleaning vessel with a purge gas prior to introduction of said cleaning medium.

5        5.    The process of claim 1, further comprising:  
flushing said cleaning vessel and said workpiece  
with carbon dioxide which is in said single fluid  
phase.

10       6.    The process of claim 1, further comprising:  
introducing inert gas into said cleaning vessel  
after said contacting step to remove said cleaning  
medium; and  
adjusting the pressure of said cleaning vessel to  
atmospheric pressure.

15       7.    The process of claim 1, wherein said single  
fluid phase is selected from the group consisting of:  
liquid, gas and supercritical fluid.

20       8.    The process of claim 1, wherein said cleaning  
medium is selected from the group consisting of carbon  
dioxide and a mixture of carbon dioxide and co-solvent.

25       9.    A process for cleaning a workpiece in a  
cleaning vessel with a cleaning medium maintained at a  
single fluid phase, said process comprising:  
introducing inert gas into said cleaning vessel;  
introducing said cleaning medium into said  
cleaning vessel;

contacting said workpiece and said cleaning medium in said single fluid phase for a period of time sufficient to clean said workpiece;

introducing inert gas after the contacting step  
5 into said cleaning vessel to remove said cleaning medium; and

adjusting the pressure of said cleaning vessel to atmospheric pressure.

- 10 10. A process for cleaning a workpiece with a cleaning medium maintained at a single fluid phase, said process comprising:
- providing a solvent delivery vessel;
  - providing a cleaning vessel;
  - 15 placing a workpiece in said cleaning vessel;
  - introducing inert gas into said cleaning vessel;
  - maintaining said cleaning vessel at a first temperature and first pressure, said first temperature and said first pressure being sufficient to produce
  - 20 said single fluid phase in said cleaning vessel;
  - introducing inert gas into said solvent delivery vessel;
  - introducing carbon dioxide and optionally co-solvent to said solvent delivery vessel to form said
  - 25 cleaning medium;
  - maintaining said solvent delivery vessel at a second temperature and second pressure, said second temperature and said second pressure being sufficient to produce said single fluid phase in said solvent
  - 30 delivery vessel;

introducing said cleaning medium into said cleaning vessel;

contacting said workpiece and said cleaning medium in said single fluid phase for a period of time  
5 sufficient to clean said workpiece;

introducing inert gas after the contacting step into said cleaning vessel to remove said cleaning medium; and

adjusting the pressure of said cleaning vessel to  
10 atmospheric pressure.

11. The process of claim 10, wherein said first pressure of said cleaning vessel and said second pressure of said solvent delivery vessel is controlled  
15 by the use of said inert gas.

12. The process of claim 10, wherein said first temperature of said cleaning vessel and said second temperature of said solvent delivery vessel is  
20 controlled by heating.

13. The process of claim 10, wherein said single fluid phase is selected from the group consisting of: liquid, gas and supercritical fluid.  
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14. The process of claim 10, wherein said cleaning medium is in the supercritical fluid phase.

15. The process of claim 10, wherein said  
30 cleaning medium is in the liquid fluid phase.

16. The process of claim 10, wherein said cleaning medium is in the gaseous fluid phase.

17. The process of claim 10, wherein said  
5 cleaning medium is in said single fluid phase prior to contacting said workpiece.

18. The process of claim 10, wherein said  
cleaning medium is selected from the group consisting  
10 of carbon dioxide and a mixture of carbon dioxide and co-solvent.

19. The process of claim 10, wherein said co-solvent is selected from the group consisting of  
15 heptane, benzene, acetic acid, methanol, 2-propanol, ethanolamine, dimethylsulfoxide, N,N-dimethylformamide, N-methylpyrrolidone and a mixture thereof.

20. The process of claim 10, wherein each of said  
20 first pressure and said second pressure is above the supercritical pressure of at least one fluid component.

21. The process of claim 20, wherein each of said  
first pressure and said second pressure is above the  
25 supercritical pressure of carbon dioxide.

22. The process of claim 10, further comprising:  
agitating said cleaning medium in said cleaning  
vessel and in said solvent delivery vessel.

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23. The process of claim 10, further comprising:

flushing said cleaning vessel and said workpiece with carbon dioxide which is in said single fluid phase.

5           24. The process of claim 10, further comprising:  
          purging said cleaning vessel with a purge gas  
prior to introduction of said cleaning medium.

          25. The process of claim 10, further comprising:  
10          separating carbon dioxide and co-solvent from said  
cleaning medium after completion of the cleaning.

          26. A storage media including instructions for  
controlling a processor for cleaning a workpiece with a  
15          cleaning medium, said storage media comprising:  
          means for controlling said processor to control  
          contacting conditions of said workpiece and said  
          cleaning medium such that said workpiece is exposed to  
          a single fluid phase of said cleaning medium, wherein  
20          said contacting is carried out for a period of time  
sufficient to clean said workpiece.

          27. The storage media of claim 26, wherein said  
means for controlling said processor to control said  
25          contacting conditions comprises at least one means  
selected from:

          means for controlling said processor to introduce  
inert gas into said cleaning vessel;

          means for controlling said processor to introduce  
30          carbon dioxide and optionally co-solvent to said

solvent delivery vessel to form a cleaning medium at said single fluid phase;

means for controlling said processor to introduce inert gas into said cleaning vessel after said

5 contacting step to remove said cleaning medium; and

means for controlling said processor to adjust the pressure of said cleaning vessel to atmospheric pressure.

10 28. The storage media of claim 26, wherein said means for controlling said processor to control said contacting conditions further comprises one or more means selected from:

means for controlling said processor to introduce  
15 inert gas into said cleaning vessel;

means for controlling said processor to maintain said cleaning vessel at a first temperature and first pressure;

means for controlling said processor to introduce  
20 inert gas into a solvent delivery vessel;

means for controlling said processor to introduce carbon dioxide and optionally co-solvent to said solvent delivery vessel to form a cleaning medium at said single fluid phase;

25 means for controlling said processor to maintain said solvent delivery vessel at a second temperature and second pressure;

means for controlling said processor to purge said cleaning vessel with a purge gas prior to introduction  
30 of said cleaning medium;

means for controlling said processor to flush said cleaning vessel and said workpiece with carbon dioxide in said single fluid phase;

means for controlling said processor to introduce  
5 inert gas into said cleaning vessel after the contacting step to remove said cleaning medium; and

means for controlling said processor to adjust the pressure of said cleaning vessel to atmospheric pressure.

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29. The storage media of claim 28, further comprising:

means for controlling said processor to control a separator means; and

15 means for controlling said processor to control means for condensing vapors to a liquid fluid phase.

30. An apparatus for cleaning a workpiece with a cleaning medium maintained at a single fluid phase,  
20 said apparatus comprising:

means for providing said cleaning medium;

a pressurizable cleaning vessel for receiving said cleaning medium and said workpiece; and

25 means for maintaining a single fluid phase of said cleaning medium in said cleaning vessel.

31. The apparatus of claim 30, wherein said means for providing said cleaning medium comprises:

30 a storage vessel for maintaining a supply of carbon dioxide;



a storage vessel for maintaining a supply of inert gas;

co-solvent supply vessel;

a pressurizable solvent delivery vessel for  
5 forming and delivering said cleaning medium;

means for providing inert gas to said solvent delivery vessel;

means for controlling the temperature of said solvent delivery vessel; and

10 an agitator for mixing carbon dioxide and said co-solvent in said solvent delivery vessel.

32. The apparatus of claim 30, wherein said means for maintaining a single fluid phase of said cleaning  
15 medium comprises:

means for controlling the temperature of said cleaning vessel.

33. An apparatus for cleaning a workpiece with a  
20 cleaning medium maintained at a single fluid phase, said apparatus comprising:

a storage vessel for maintaining a supply of carbon dioxide;

a storage vessel for maintaining a supply of inert  
25 gas;

co-solvent supply vessel;

a pressurizable solvent delivery vessel for forming and delivering said cleaning medium;

a pressurizable cleaning vessel for receiving said  
30 workpiece, said pressurizable cleaning vessel having an inlet for receiving said cleaning medium and an outlet;

a letdown valve in communication with said outlet;  
means for placing said solvent delivery vessel in  
communication with said co-solvent supply vessel;  
means for controlling the temperature of said  
5 solvent delivery vessel;  
means for controlling the temperature of said  
cleaning vessel;  
an agitator for mixing carbon dioxide and said co-  
solvent in said solvent delivery vessel;  
10 means for conveying at least one of carbon dioxide  
and inert gas from said storage vessels for maintaining  
a supply of carbon dioxide or said inert gas to said  
solvent delivery vessel and said cleaning vessel;  
a first valve and a second valve in communication  
15 with said means for conveying at least one of carbon  
dioxide and inert gas; said first valve being in  
communication with said storage vessel for maintaining  
a supply of carbon dioxide and said storage vessel for  
maintaining a supply of said inert gas; said second  
20 valve being in communication with said solvent delivery  
vessel; and  
a third valve; said third valve being in  
communication with said second valve, solvent delivery  
vessel and said cleaning vessel for conveying one or  
25 more of said cleaning medium, carbon dioxide and said  
inert gas to said cleaning vessel.

34. The apparatus of claim 30, further  
comprising:

a separator means in communication with said  
letdown valve having a first outlet and a second outlet  
at a lower end of said separator means; and

means for condensing vapors to a liquid fluid  
5 phase, in communication with said first outlet of said  
separator means.